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ABSTRACT

The goal of this research is to compare the effectiveness of two teaching methods (inducing a cognitive conflict, or ICC, versus direct teaching, DT) for students of two academic levels (low versus high) regarding gains in the ability to use the control of variables strategy. 121 students who learned in a heterogeneous school were divided into four experimental groups in a 2X2 design. Results showed no main effect of teaching method, a significant main effect for level of students and a significant interaction effect between level of students and teaching method. The findings showed that the ICC teaching method was more effective for high level students, while the DT method was more effective for low level students. This interaction effect was preserved in a retention test that took place 5 months after instruction. These findings show that high level students benefited from the ICC teaching method while the DT method delayed their progress. In contrast, low- level students benefited from the DT method while the ICC teaching method delayed their progress. These findings confirmed our hypothesis that inconclusive findings regarding the effectiveness of the ICC method can be explained by its opposite effect on students of different academic levels. (Author)

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Cognitive conflict, direct teaching and student's academic level

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Abstract

The goal of this research is to compare the effectiveness of two teaching methods (inducing a cognitive conflict, or ICC, versus direct teaching, or DT) for students of two academic levels (low versus high) regarding gains in the ability to use the control of variables strategy. 121 students who learned in a heterogeneous school were divided into four experimental groups in a 2X2 design. Results showed no main effect of teaching method, a significant main effect for level of students and a significant interaction effect between level of students and teaching method. The findings showed that the ICC teaching method was more effective for high level students, while the DT method was more effective for low level students. This interaction effect was preserved in a retention test that took place 5 months after instruction. These findings show that high level students benefited from the ICC teaching method while the DT method delayed their progress. In contrast, low -level students benefited from the DT method while the ICC teaching method delayed their progress. These findings confirmed our hypothesis that inconclusive findings regarding the effectiveness of the ICC method can be explained by its opposite effect on students of different academic levels.

Objective

The objective of this research is to compare the effectiveness of two teaching methods (inducing a cognitive conflict, or ICC, versus direct teaching, or DT) for students of two academic levels (low versus high) regarding gains in the ability to use the control of variables thinking strategy.

Significance

This study has important implications for theory and practice. From a theoretical point of view, the findings explain why empirical studies often don't show the expected contribution of cognitive

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conflict to learning. Our findings show that high-level students indeed benefit from instruction that induces cognitive conflict. The learning of low-level students, however, is hindered by teaching that induces a cognitive conflict (ICC method), compared to teaching that employs direct instruction (DT method). Since subjects in many studies consist of a heterogeneous group of students, the detrimental effect of using the ICC method for low level students may conceal any positive effect this method holds for high level students. From a practical point of view, the findings show the significance of using diverse teaching methods because using only one of the two methods described above would limit the progress of some students.

Theoretical underpinnings

Most of the models proposed to explain conceptual change emphasize the central role cognitive conflict plays in conceptual change. But although cognitive conflict has been considered essential for learning since the days of Piaget, empirical studies show controversial results regarding its effectiveness (e.g., Dreyfus, Jungwirth & Eliovitch, 1990; Chan and Al., 1997; Limon, 2001). Researchers suggest several explanations as to why the cognitive conflict strategy seems not to work in the classroom- at least to the extent expected (Limon, 2001). First, students often fail to reach a stage of *meaningful* conflict that requires a certain degree of both prior knowledge (Chinn and Brewer, 1993) and reasoning abilities (Kuhn, Amsel and O'loughlin; 1988). Second, students may not have an appropriate degree of motivation (goals, values and self - efficacy) that are potential mediators in the process of conceptual change (Pintrich, Marx and Boyse, 1993; Pintrich, 1999).

Students with low academic aptitudes and achievements tend to have a lower degree of prior knowledge, less advanced reasoning abilities and a lower degree of motivation than students with high academic aptitudes and achievements. These explanations thus suggest that as a group, students with low academic aptitudes and achievements will tend to benefit from instruction using cognitive conflict less then students with high academic aptitudes and achievements. Perhaps such instruction even obstructs the learning of low-achieving students compared to other teaching methods such as direct teaching. Thus, the inconclusive findings regarding the effectiveness of teaching with cognitive conflict may be caused, at least partially, by the fact that participants in many studies consist of students with varied academic levels. An interaction effect between students' academic level and teaching method may conceal any effects that cognitive conflict might hold for some students. The goal of this study is to test this hypothesis empirically in the context of teaching the control of variables strategy.

The role of cognitive conflict in teaching the control of variables strategy has been highlighted in the meta-analysis conducted by Ross (1988). An investigation of the many different curricula used in teaching the control of variables strategy revealed that the most powerful teaching methods involve some form of cognitive conflict in which students' conceptions and expectations are overtly challenged. This creates a disequilibrium that is then resolved when students shift their allegiance from a primitive schema to a more sophisticated one. The key to that tactic is the demonstration that students' current methods for designing an experiment are inadequate according to their own terms (e.g., Lawson & Wollman, 1976; Case, 1977; Lewis, 1986, Ross and Maynes, 1983). The present study employs this idea, comparing between the effectiveness of teaching the control of variables strategy using a cognitive conflict and its teaching using direct instruction.

Design and procedures

Experimental design: This study employs a 2X2 design, with level of students and teaching method as independent variables, and with gain in frequency of valid inferences as a dependent variable (see below). Students were assessed three times: pre-test interviews that took place prior to instruction, post - test interviews that took place immediately after instruction and retention written tests that took place five months after instruction.

School description: Subjects were ninth grade students (ages 14-15) in a large comprehensive high school (grades 9-12) in a small town. The student population is heterogeneous, consisting of students from low, middle and middle - high social-economic background. About 240 pupils study in eight ninth grade classrooms. In this school students are divided into two tracks: medium and high. The medium level track consists of three classes whose students are defined by the school as students with low academic aptitude. The high level track consists of five classes whose students are defined by the school as students with high academic aptitude. All students take the same biology curriculum in ninth grade. Assortment into the two levels is carried out according to two sources of information: (a) A recommendation written jointly by the home - room teacher and the counselor in the elementary schools in which the students had learned in eighth grade. (b) Students' mean eight grade marks in three subjects. Consequently, large differences existed between the two tracks while classes within each track are similar to each other.

Subjects: 121 ninth grade students participated in this study, 67 students learned in the high level track and 54 students learned in the medium level track. The larger number of students in the high-level track was inevitable because of larger class sizes in this track. Students' ages at the beginning of the study ranged between 13 years and 11 months to 14 years and 10 months. Two biology teachers participated in this study. Both teachers had a Bachelor degree in biology and taught full time in this school.

Instrumentation: A series of simple computerized simulations -Investigation of Microworlds were designed for the purpose of teaching the control of variables strategy (Zohar, 1996). Students investigated the microworlds by performing simulated experiments, using a set of activity - sheets that guided them through the activity. The microworlds were used for both teaching purposes and assessment (see below). Two different teaching sequences in which students engaged the computer simulations for four class periods were developed. One led students to a cognitive conflict (ICC, or Inducing a Cognitive Conflict teaching method). The second teaching method begun by direct instruction of the control of variable rule (DT, or Direct Teaching method).

Assessment: Students' gains in reasoning abilities were assessed by two sets of individual interviews, one prior to instruction (used as a pre-test) and the other immediately after its completion (used as a post-test). Each interview lasted 15-20 minutes. During the interview students were asked to perform three simulated "experiments" with the microworlds, to draw inferences and to justify them. The interview followed the protocol developed by Kuhn & al., (1992; 1995) for a study conducted with a similar set of microworlds. Interview transcripts were analyzed using the coding system developed and validated by Kuhn & al. (1992; 1995). Following coding, the frequency of valid inferences made by each student and the mean pre- and post-test scores for each experimental group were calculated.

The retention test consisted of a written questionnaire that presented fictitious experiments conducted with the microworlds and then asked students to draw conclusions from these experiments and to justify them. Students' written inferences were analyzed using the same coding system as in the interviews.

Experimental groups: The study consisted of four experimental groups (each consisting of two lab groups): high level students taught by the ICC method, high level students taught by the DT

method, low level students taught by the ICC method, and low level students taught by the DT method.

Findings

The data was analyzed using a two-way analysis of variance. Findings are presented in Tables 1 and 2.

Table 1: Mean gains in interview tasks

	Level	Teaching method					
		ICC		DT		Total	
		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Proportion of valid inferences	High	0.69	0.36	0.56	0.45	0.63	0.40
	Low	0.24	0.36	0.55	0.44	0.40	0.43
	Total	0.50	0.42	0.55	0.44	0.53	0.43

Table 2: Effects of teaching method, level of students and interaction between teaching method and level of students (in interview tasks)

	Teaching method		Level of students		Interaction	
	F	P	F	P	F	P
Proportion of valid inferences	1.46	0.23	9.33	0.00	8.68	0.00

Comparing the two teaching methods: A comparison of the two teaching methods showed no main effect for teaching method ($f=1.46$; $p=0.23$). Indeed, the difference between the two treatments was negligible ($\bar{X} = 0.50$ for the ICC treatment and $\bar{X} = 0.55$ for the DT treatment).

Comparing low and high level students: A comparison between the gains of low and high level students showed a significant main effect for student level ($f=9.33$, $P<0.00$). This reflects a large difference between the gains of the two groups ($\bar{X} = 0.63$ for high level students and $\bar{X} = 0.40$ for the low - level students).

Interaction between teaching method and level of students

Our hypothesis predicted an interaction between teaching method and student level. Specifically, the theoretical considerations presented in the literature review suggested that the

ICC method would be more effective for high-level students while the DT method will be more effective for low-level students. The data analysis confirmed this prediction. The analysis of variance showed a significant interaction effect ($F_{1, 117}$=8.68; P<0.00) between level of students and teaching method (see Table 2).

An examination of the data presented in Table 1 shows that in the ICC teaching method the increase in the frequency of valid inferences was almost three times larger for the high-level students than for the low -level students ($\bar{X}$ = 0.69 and $\bar{X}$ =0.24 respectively). In the DT method, the increase in the frequency of valid inferences was almost the same for the high-level students and for the low-level students ($\bar{X}$ = 0.56 and $\bar{X}$ = 0.55 respectively). The progress made by low level students in the DT treatment was approximately twice as large as in the ICC treatment ($\bar{X}$ =0.44 versus $\bar{X}$ =0.24 respectively).

Findings from retention test

The findings form the retention test show the same pattern as the findings from the interviews data. There is no main effect for teaching method, a significant main effect for student level and a significant interaction effect between student level and teaching method (see Table 3). Since only 65% of the students who took part in the first part of the study answered the written retention tests, results form this part of the study should be treated with cautious. Taking this qualification into consideration, however, the results show that the interaction effect was preserved for at least five months after instruction.

Table 3: Results of retention test

Level of Students	Teaching method						Teaching method		Level of students		Interaction	
	ICC		DT		Total		F	P	F	P	F	P
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	0.01	0.91	9.18	0.00	4.80	0.03
High	3.5	2.0	2.5	1.7	3.0	2.0						
Low	1.3	1.5	2.2	2.1	1.8	1.9						
Total	2.5	2.1	2.3	1.9	2.4	2.0						

These findings show that the high level students benefited from the ICC teaching method while the DT method delayed their progress. In contrast, the low -level students benefited from the DT method while the ICC teaching method delayed their progress. The findings confirm our hypothesis that inconclusive findings regarding the effectiveness of teaching with cognitive conflict may be caused by an interaction effect between students' academic level and teaching method.

Finally, It should be noted that the scope of our conclusions is limited to the learning environment investigated in this study. Further studies are required for generalizations to other circumstances. Specifically, future research should ask whether pedagogical measures designed to make the cognitive conflict more accessible to low -achieving students would enhance the effect of the ICC method for students of low academic level. These pedagogical means may include measures such as preparatory teaching of the prior knowledge and of the reasoning strategies required for meaningful conflict, or more guided teaching that would let students become aware of the conflict but reduce the frustration that may interfere with their learning.

References

Case, R. (1977). The process of stage transition in cognitive development. *Final report to the Institute of Child Health and Development* . Berkeley, Ca: University of California.

Chan, C., Burtis, J., & Bereiter, C. (1997). Knowledge building as a mediator of conflict in conceptual change. Cognition and Instruction, 15, 1-40.

Chinn, C. A., & Brewer, W. F. (1993). The role of anomalous data in knowledge acquisition: a theoretical framework and implications for science concepts. Learning and Instruction, 4, 27-44.

Dreyfus, A., Jungwirth, E., & Eliovitch, R. (1990). Applying the "cognitive conflict" strategy for conceptual change – some implications, difficulties and problems. *Science Education*, 74, 555-569.

Kuhn, D., Amsel, E. & O'Loughlin, M. (1988). The Development of Scientific Thinking Skills. Orlando, FL: Academic Press.

Kuhn, D., Schauble, L. & Garcia-Mila, M. (1992). Cross- domain development of scientific reasoning. *Cognition and Instruction, 9*(4), 285-327.

Kuhn, D., Garcia-Mila, M., Zohar, A., & Anderson, C. (1995). Strategies of knowledge Acquisition. To be printed in: *Monographs of the Society for Research in Child Development (MSRCD).*

Lawson, A. E., & Wollman, W. T. (1976). Encouraging the Transition from concrete to formal cognitive functioning- An experiment. *Journal of Research in Science Teaching, 13*, 413-430.

Lewis, N. (1986). A study of the effects of concrete experiences on the problem solving of tenth grade students. Doctoral Dissertation, University of Southern Mississippi, Microfilms No. 77-15756.

Limon, M. (2001). On the cognitive conflict as an instructional strategy for conceptual change: a critical appraisal. Learning and Instruction, 11, 357-380.

Ross, J. A. (1988). Controlling variables: a meta-analysis of studies. Review of Educational Research, 58(4), pp. 405-437.

Ross, J. A., and Maynes, F. J. (1983). Experimental problem -solving: An instructional improvement field experiment. *Journal of Research in Science Teaching, 20*, 543-556.

Zohar, A. (1996). Transfer and retention of reasoning skills taught in biological contexts. *Research in Science and Technological Education, 14*, 205-219.

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